§4. The Structural Stability and Growth Process of Er_2O_3 In-situ Coating on V-4Cr-4Ti

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Self-cooled Li/V-alloy blanket is thought to be a very attractive concept for fusion. One of the critical issues for this blanket concept is the large magneto-hydrodynamic (MHD) pressure drop when liquid Li flows in a metallic duct under a magnetic field. A promising solution is to apply an electrically insulating coating on the inner wall of metallic ducts. In the previous studies, the authors showed the feasibility, characteristics and growth kinetics of in-situ Er_2O_3 coating by exposing V-4Cr-4Ti in liquid Li doped with Er. In this report, the structural stability and growth mechanism of Er_2O_3 coating were shown.

One of the optional methods to make the in-situ coating is to form the coating in Li doped with Er in a factory after assembling of parts or in a reactor site before the operation. Doping of Er into the flowing Li is necessary for forming the Er_2O_3 coating. After the formation of the coating, however, it may be preferred to remove both dissolved and undissolved Er from Li for the purpose of keeping the purity of Li for heat-transfer or tritium-recovery purposes, and of minimizing negative effects of Er on tritium breeding ratio (TBR) during the operation. In this case, Er_2O_3 coating will face a pure Li environment. For verification of this option, the stability of the coating once formed in Li (Er) should be tested in pure Li. In this study, the re-exposure of the coating once formed in Li (Er) was carried out in pure Li to verify the potential stability of Er_2O_3 coating without an Er supply. Fig. 1 shows the change of the coating thickness for the two cases of Li chemical histories. The re-exposure in pure Li at 973K for 300h did not influence the thickness of the coating once formed in Li (Er) at 973K for 100h.

Fig. 2 shows the effects of temperature change during Li exposure on the thickness of the coating. The thickness of the coating is quite different at 873K and 973K. With the stepwise increase in temperature from 873K to 973K, the growth rate increases but is smaller than that at the constant temperature of 973K. After long exposure the thickness for the case of stepwise temperature change is close to that of the constant temperature. This result may suggest the nucleation and pre-coating at 873K followed by the growth at 973K as a process for coating production.

Fig. 3 shows a general phenomenological model schematically on nucleation and growth processes of the surface layer on V-4Cr-4Ti in liquid Li doped with Er. Here V[O]+(Ti-O) is the vanadium alloy charged by oxygen showing as both solid solution and titanium oxide, and Li[Er][N,O] is Li doped with Er and containing the impurity of N and O. The ordinate *d=0* is the initial interface between solid and liquid metal. The model on formation of coating on V-alloys described that the growth of Er_2O_3 coating after quick nucleation is controlled by delivery of either oxygen from substrate or erbium from Li to the interface. The model also showed the formation mechanism of the observed intermediate layer.

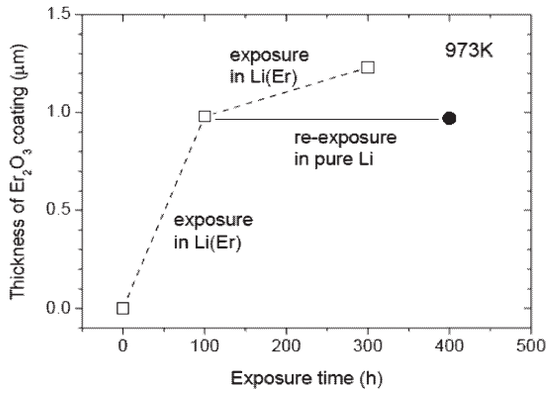

Fig.1 Change of coating thickness in two cases of Li chemical histories.

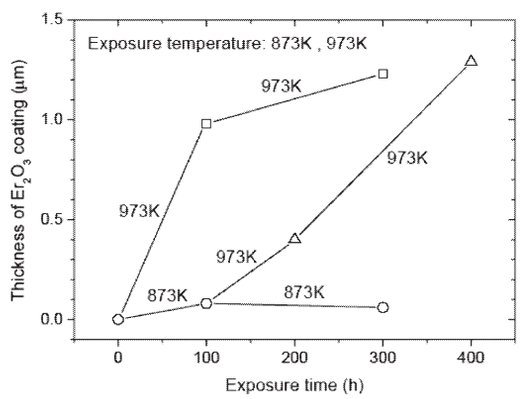

Fig.2 Effects of temperature change during exposure to Li (Er) on thickness of coating.

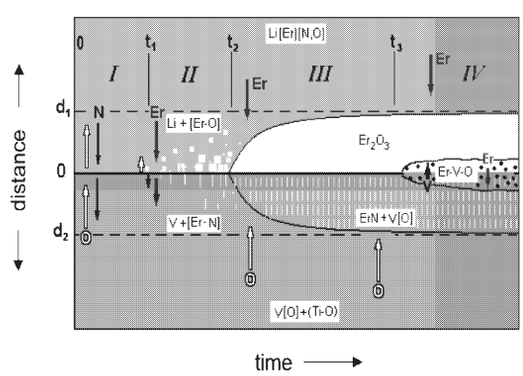

Fig.3 Scheme on nucleation and growth process of surface layers on V-4Cr-4Ti in liquid Li (Er).